Asphalt Reinforcement : 10 years of Experience and Development

A. J. T. Gilchrist & J. Paul
Netlon Limited, Blackburn, UK

ABSTRACT: Many synthetic inclusions have been used within asphalt layers in an attempt to extend the life of pavements by delaying the onset of failure by permanent deformation or cracking. This paper examines the extensive programme of testing and development of a stiff polypropylene geogrid leading to the creation of a new composite material.

A four year programme of research work at the University of Nottingham quantified the benefits of including a stiff reinforcing geogrid within the pavement.

The major requirement is for the geogrid to interlock with the aggregate and carry tensile forces at low strain for a considerably longer period of time than the bitumen itself can sustain. This directly reduces the rate of crack propagation and by confining the asphalt particles within the loaded zone can considerably reduce permanent deformation.

By combining a stiff reinforcing geogrid with a geotextile paving fabric, installation is simplified and the overall performance is improved.

1 INTRODUCTION:

Stiff polypropylene geogrids for the reinforcement of asphalt were first introduced in 1982 the first project being at Canvey Island in England.

Between 1981 and 1983 an extensive programme of research was carried out at the University of Nottingham under the supervision of Professor S F Brown. Laboratory testing work investigated the benefits of the grid with respect to the control of permanent deformation, the control of reflective cracking and improvement of the fatigue life of the pavement. The research identified a number of significant benefits due to the use of a stiff polypropylene geogrid in the asphalt layers.

2 RESEARCH:

The research work at the University of Nottingham was carried out over approximately 4 years and consisted of simulative testing leaving installation techniques to be developed in the field. Details of the laboratory work have been published by Brown et al (1985a), and Brown et al (1985b) the major components of which were;

2.1 PERMANENT DEFORMATION TESTING:

Testing was carried out using 1.2m x 0.34m slabs of different asphalt mixes laid on a very stiff base to eliminate as much as possible the effects of the lower pavement. Repeated wheel loading was applied at a constant speed of 8km/hr with a contact pressure of 415KPa and air temperature was maintained constant at 30^0C.

Tests on reinforced and unreinforced specimens showed that for all asphalt types, the reinforced specimens were more resistant to permanent deformation. It was also shown that the lateral flow of the material away from the loaded area was well restrained by the grid.

2.2 REFLECTIVE CRACKING:

This test involved asphalt beams 525mm long by 150mm wide and 100mm deep supported on a stiff base and subjected to vertical cyclic loading. A 10mm wide joint in the base was used to simulate a joint in a rigid pavement.

In the reinforced specimens the grid was installed either directly above the joint or located between 25% and 50% of the depth of the beam above the joint. These locations represented a rigid pavement being overlaid for the first time and also a previously overlaid rigid pavement having another overlay applied.

Results showed that when the grid was installed directly above the joint the crack propagation could be arrested completely even after over 1000000 cycles of load. With the grid located within the depth of the beam the crack continued to propagate upwards but at a much reduced rate taking approximately four times longer to reach to surface. It then remained as a micro crack without major deterioration of the surface.

These small scale tests used to examine pavement deformation and reflective cracking performance were repeated in the full scale Pavement Test Facility at the University of Nottingham and the significant increase in performance was confirmed at full scale.

2.3 FATIGUE:

These tests examined similar beams to those used in the reflective cracking tests although the base was slightly less stiff and there was no simulated joint on the base. However, a saw cut was made in the base of the slab to locate the point of crack initiation. Only vertical cyclic loading was used and strains were measured at various points over the depth of the slab.

Results showed that in general the life of a pavement was extended by a factor of 10 to a given level of traffic induced strain within the asphalt (microstrain). To gain this benefit the grid should be positioned at the base of the asphalt layer.

3 FULL SCALE TRIALS:

Many full scale trials were carried out in different geographical and climatic regions which led to a number of installation techniques being developed to suit local conditions.

The first installation of a stiff polypropylene grid in reinforced asphalt was at Canvey Island, Essex in Spring 1982 where 10000m^2 of the grid was used to control reflective cracking over cracked pavement quality concrete. Since that time the road has performed as expected and further sections of the road have been overlaid based on the original work carried out.

In 1984, another large trial was carried out in Kuala Lumpur in Malaysia. In this case the pavement was constructed over a soft clay subgrade, and consisted of a thin sand sub-base under a crushed rock road base and surfaced with 40mm of asphaltic concrete.

The grid was installed over part of the length below the wearing course with, in places, an additional layer of biaxially oriented geogrid below the crushed rock road base.

Trafficking was carried out using standard road vehicles loaded and weighed at the quarry weigh station. Permanent deformation was measured and related to the number of standard axle passes. Early failure of the pavement was achieved due to severe rutting and cracking of the thin construction while rutting was significantly reduced and no cracks were evident in the reinforced sections. The reduction in rutting and improvement of the fatigue life of the pavement due to the geogrid reinforcement confirmed the results obtained in the laboratory trials.

From the results of laboratory and field trials it was possible to derive an analytical design method incorporating stiff polypropylene geogrids which is based on the improvement in the initial traffic induced strain capacity of the asphalt related to the number of axle passes i.e. fatigue life.

4 DEVELOPMENT OF THE INSTALLATION TECHNIQUE:

A large number of installations in different countries led to the development of a simple and rapid installation technique, the basic component of which are:

4.1 The leading edge of a roll of geogrid is fixed to the road surface using clips and nails or drilled fixings.

4.2 Rolls are joined together using hog rings to produce lengths of up to 400m.

4.3 The geogrid is attached to a spreader beam and tensioned to around 0.5% strain. The free end is then similarly fixed to the road and the beam removed.

4.4 To allow mechanical paving the geogrid is dressed with either a bitumen spray and stone chippings, a thin hand spread pad coat or a slurry seal.

4.5 Mechanical paving can then take place over the dressed grid.

5 DEVELOPMENTS:

Although the technique for installing the geogrid gained rapid acceptance, methods to improve the technique were constantly being investigated.

Work began in 1990 to examine the benefits of bonding a geotextile to the geogrid in order to provide a material which could be installed without the need to fix, tension and dress the material before paving and which also provided full bond between the layers of bituminous material.

Geotextile fabrics are used within the bituminous layers of pavements primarily to waterproof the structure. It is generally accepted that low stiffness fabrics are not able to prevent reflective cracking but when saturated with bitumen, they do provide a barrier to water passing into the foundation. Research has shown that inclusion of a fabric can slightly reduce the bond between layers, however it has also been shown that variability in the bond over an area can be reduced and in fact the average bond is generally increased (Fock 1989).

In 1990, a composite material comprising a stiff polypropylene geogrid thermally bonded to a polyester needle punched geotextile was produced. An installation procedure was developed based on the technology already available for the installation of paving fabrics. This involved spraying the road surface with an even film of either bitumen emulsion or straight run 200 pen bitumen and immediately laying the composite, geotextile-side down onto the treated surface. Mechanical lay-down equipment ensures that the material is slightly tensioned and all ripples are removed, Fig 1.

As the bitumen cures the composite material is firmly held in intimate contact with the pavement and mechanical paving can take place directly on top, Fig 2.

Several trial installations were carried out in the UK, Europe and USA. Bitumen emulsion was used when the geogrid composite was to be installed by hand while 200 pen straight run bitumen was used with mechanical lay-down equipment. Polymer modified emulsions were also used to improve cold weather installation.

In order to ensure production of a consistent material and to create a product specification, a series of peel and shearing tests were developed using standard tensile testing equipment. This allowed different fabric types and bonding temperatures to be examined. From a wide range of production trials the optimum performance was achieved from a non-woven needle punched geotextile which includes secondary stitching to control its final thickness and hence the quantity of bitumen which is absorbed. The designation of the composite is Tensar AR-G.

Many of the full scale pavement installations are being monitored but a further series of laboratory test have been carried out, again at the University of Nottingham. These tests examined the influence of the geogrid composite on the shear resistance of the sandwiching bituminous layers. This ensured that there was no excessive reduction in shear when comparing reinforced to unreinforced slabs. Also considered was the performance of the composite in controlling reflective cracking and in the improvement of the pavement fatigue life. The initial findings showed very close correlation with the original tests carried out on the geogrid alone ten years previously.

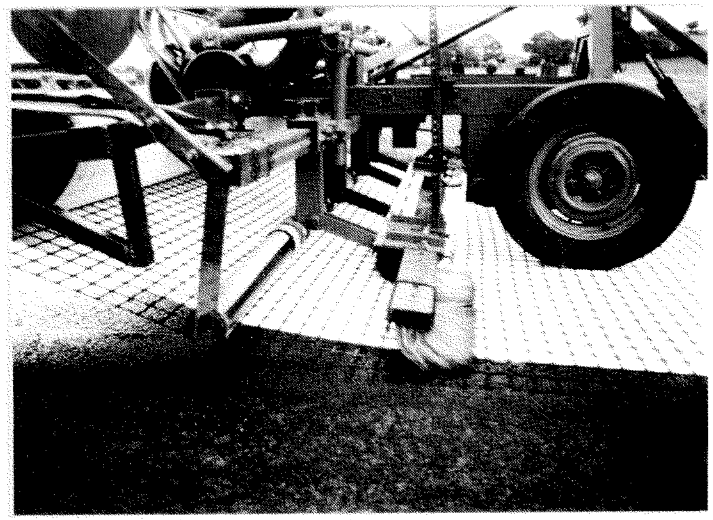

Fig 1 Laying of composite

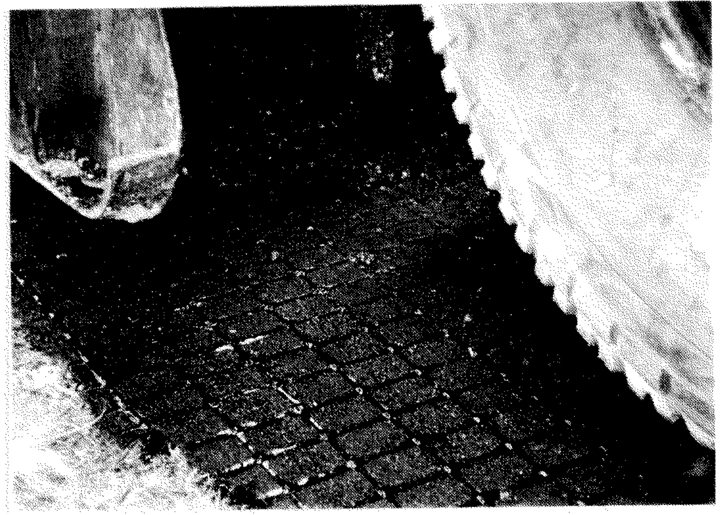

Fig 2 Paving on composite

In several full scale pavement installations, cores have been taken and subjected to shear testing which has confirmed that there is no significant loss in bond when compared with the use of a geogrid alone.

6 CASE STUDY

The B3004 in Hampshire, England, carries heavy local traffic over soft saturated ground on low embankments. Failure of the existing surfacing has been caused by geotechnical failure of the subgrade leading to the formation of a longitudinal crack along the centre of the lane with evidence of severe lateral and vertical deformation. In 1991, a Hot Rolled Asphalt overlay was laid on the road two sections of which were reinforced using proprietary systems leaving an unreinforced control section.

The existing road surface was first regulated with fine asphalt to a thickness of 30mm. Bitumen emulsion was then sprayed at a rate of around 1.5 l/m^2 and the geogrid composite material was rolled out immediately as the emulsion cured. To ensure full curing of the emulsion, vigorous brushing was then carried out.

The other proprietary system involved the use of a self-adhesive woven geogrid and was installed directly onto the regulated surface.

When the bitumen had fully cured, 40mm of hot rolled asphalt was overlaid by conventional paver at a maximum temperature of 165°C. No evidence of movement was detected during installation.

The site has now been open to traffic for over two years and although the control and the section containing the self-adhesive geogrid are displaying severe cracking coincident with the original crack, there is no evidence of any cracking in the section reinforced with the geogrid/geotextile composite material.

7 CONCLUSIONS:

7.1 Tensar high strength stiff polypropylene geogrids and geogrid/geotextile composite materials are suitable for the effective reinforcement of asphalt layers in pavements and appropriate installation techniques have been developed.

7.2 The geogrid is resistant to normal paving temperatures.

7.3 The susceptibility of the geogrid with regard to rate of loading and pavement temperature is significantly less than that of bitumen itself.

7.4 When placed at a depth of between 0.2 and 0.3 times the width of the wheel load, effective resistance to permanent deformation is increased with life to a critical value being increased by a factor of around 3.

7.5 When placed immediately above an existing cracked or jointed surface prior to the application of an asphaltic overlay, effective resistance to reflective cracking is provided.

7.6 Increase in the pavement fatigue life by a factor of about 10 can be achieved when the geogrid or geogrid composite is installed at the base of an asphaltic layer.

8 REFERENCES

Brown et al (1985a) Polymer Grid Reinforcement of Asphalt, *Annual Meeting of the Association of Asphalt Paving Technologists*, San Antonio, Texas

Brown et al (1985b) The Use Of Polymer Grids for Improved Asphalt Performance, *Eurobitume Conference*, The Hague, Netherlands

Fock, G, (1989) The use of paving felts to influence the life expectancy and permanent adhesion of asphalt road surfaces, *1st International RILEM Conference*, Liege

9 BIBLIOGRAPHY

9.1 Netlon Limited, Tensar Grid Reinforced Asphalt, October 1987.

9.2 Gilchrist, A J T, Control of reflection cracking in pavements by the installation of polymer geogrids, Paper presented at the 1st International RILEM Conference, Liege, 1989.